

ADDITIONAL MOON TRACKING COMPUTER AND CALCULATOR PROGRAMS



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MODIFICATIONS TO HP2000C PROGRAM

In bulletin AS-49-13, there is a moon tracking program written for the HP2000C computer. In that particular program the equations for elevation were based on the center of the earth. As a result, there is about a 10 error in the elevation number. By changing one statement and adding another, the error can be reduced to under 0.20. The following statements show the program before and after the changes were made. Also, in statement numbers 280 and 350 the line reads FOR N=1 to 25. If these statement lines are changed to FOR N=1 to 31, then 31 days of data can be requested instead of being limited to 25 days.

BEFORE

```
1300 LET H=L6-G
1310 REM:CALCULATION OF ELEVATION,E,OF OBJECT
1320 LET F3=COS(L5)*COS(H)*COS(D1)+SIN(D1)*SIN(L5)
1330 LET F2=SQR(1-(E3*E3))
1340 LET E=ATN(F3/F2)
1350 IF E<0 THEN 1810
1360 IF F>I6*R5 THEN 1810
1370 REM:CALCULATION OF AZIMUTH,A,OF OBJECT
1380 LET A2=SIN(D1)/((COS(L5)*COS(E)))
1390 LET A1=SIN(L5)*SIN(D1)+COS(L5)*COS(D1)*COS(H)
```

AFTER

```
1300 LET H=L6-G
1310 REM:CALCULATION OF ELEVATION,E,OF OBJECT
1320 LET F3=COS(L5)*COS(H)*COS(D1)+SIN(D1)*SIN(L5)
1330 LET E2=SQR(1-(E3*E3))
1340 LET E=ATN((E3/E2)-(1/(61.33*E2)))
1345 LET F=ATN(E3/E2)
1350 IF E<0 THEN 1810
1360 IF E>I6*R5 THEN 1810
1370 REM:CALCULATION OF AZIMUTH,A,OF OBJECT
1380 LET A2=SIN(D1)/((COS(L5)*COS(F)))
1390 LET A2=A2-(SIN(L5)/COS(L5))*(SIN(F)/COS(F))
```

The following program is a version of Lance Collister's (WB7CCI) original moon tracking program written in GE BASIC. This particular version was modified by Jay Liebmann, K5JL, to run on a Mits Altair 8800B. The program requires about 6700 bytes of memory. For those with a smaller memory, Jay has a stripped down version of the program which requires only 4000 bytes.

```
500 DIM F(31),V(31),Y(31),Q(31),S(31)
560 P5=2.0000000000*3.1415926535
570 D5=360.0000000000/P5
580 R5=P5/360.0000000000
582 DEF FNA(X)=INT(X*D5*10+.5)/10
584 DEF FNB(X)=(X-INT(X))*P5
585 PRINT"WHAT ARE THE STATION CALL LETTERS";
587 INPUT WS
590 PRINT"WHAT IS YOUR LATITUDE IN DEGREES,MINUTES";
600 INPUT L5,U5
610 PPINT"WHAT IS YOUR LONGITUDE IN DEGREES,MINUTES";
620 INPUT L6,U6
630 L5=(L5+U5/60)*R5
640 L6=(L6+U6/60)*R5
650 PRINT"WHAT IS DESIRED PRINTING INCREMENT IN MINUTES";
660 INPUT I
670 PRINT "DO YOU ONLY WANT PRINTOUT WHEN THE MOON IS NEAR THE HORIZON";
690 INPUT BS
700 IF BS="YES" THEN 730
710 LET I6=100
720 GOTO 800
730 PPINT"BELOW WHAT ELEVATION IN DEGREES DO YOU WANT PRINTOUT"
731 PRINT"TO OCCUP";
740 INPUT I6
750 PPINT"WHAT ARE THE GMT MONTH, DAY, YEAP DESIRED";
760 FOR N=1 TO 31
770 INPUT F(N),V(N),Y(N)
780 IF F(N)=0 THEN 860
785 NEXT N
790 GOTO 760
800 PRINT"WHAT APE THE GMT MONTH, DAY, YEAP, TIME BEGINNING, TIME ENDING
820 FOR N= 1 TO 31
830 INPUT F(N),V(N),Y(N),Q(N),S(N)
840 IF F(N)=0 THEN 860
845 NEXT N
850 GOTO 820
860 N5=N-1
870 FOR N=1 TO N5
880 IF BS="YES" THEN 900
890 GOTO 930
900 E1=2400
910 B=0
920 GOTO 950
930 E1=S(N)
940 B=Q(N)
950 M=F(N)
960 D=V(N)
970 Y=Y(N)
980 Y I=Y-(INT(Y/100)*100)
990 PRINT
```

```

1000 PRINT
1010 PRINT"POSITION OF THE MOON ON";M$"/";D$"/";Y$;"GMT FROM"" WS
1020 PRINT
1030 PRINT" GMT"," AZ"," EL"," GHA"," DEC"
1040 PRINT" ---"," --"," --"," ---"," ---"
1050 PRINT
1060 I1=2
1080 IF M>=3 THEN 1160
1090 IF INT((Y-1853)/4)<11 THEN 1120
1100 C1=-1
1110 GOTO 1130
1120 C1=0
1130 J1=365*(Y-1853)+D+30*(M+9)+INT((M+10)/2)
1140 J2=INT((Y-1853)/4)+1+C1
1150 GOTO 1270
1160 IF INT((Y-1852)/4)<11 THEN 1190
1170 C1=-1
1180 GOTO 1200
1190 C1=0
1200 IF M=9 THEN 1240
1210 IF M=11 THEN 1240
1220 C2=0
1230 GOTO 1250
1240 C2=1
1250 J1=365*(Y-1852)+D+30*(M-3)+INT((M-2)/2)
1260 J2=INT((Y-1852)/4)+C1+C2
1270 J=J1+J2
1280 T1=J-17472.5
1290 D9=(B-INT(B/100)*100)+INT(B/100)*60
1300 D6=(E1-INT(E1/100)*100)+INT(E1/100)*60
1310 D7=D9-D6
1320 D8=D7-I
1330 IF D7>0 THEN 1350
1340 GOTO 1380
1350 IF D8>=0 THEN 2220
1360 B=E1
1380 T=(B-INT(B/100)*100)/1440+INT(B/100)/24
1390 T5=T1+T
1400 K1=FNB(.751213+.036601102*T5)
1410 K2=FNB(.822513+.0362916457*T5)
1420 K3=FNB(.995766+.0027377852*T5)
1430 K4=FNB(.974271+.0338631922*T5)
1440 K5=FNB(.0312525+.0367481957*T5)
1450 L8=K1+.658*R5*SIN(2*K4)+6.289*R5*SIN(K2)
1460 L8=L8-1.274*R5*SIN(K2-2*K4)-.186*R5*SIN(K3)
1470 L8=L8+.214*R5*SIN(2*K2)-.114*R5*SIN(2*K5)
1480 L8=L8-.059*R5*SIN(2*K2-2*K4)-.057*R5*SIN(K2+K3-2*K4)
1490 K6=K5+.6593*R5*SIN(2*K4)+6.2303*R5*SIN(K2)-1.272*R5*SIN(K2-2*K4)
1500 L7=5.144*R5*SIN(K6)-.146*R5*SIN(K5-2*K4)
1520 LET D1=COS(L7)*SIN(L8)*.397821+SIN(L7)*.917463
1530 LET D1=ATN(D1/(5QR(1-D1^2)))
1531 G1=50+.5+((D1)/(.792))*D5
1532 G2=80+((D1)/(.808))*D5
1533 G3=141.5-((D1)*(.738)*D5)
1534 G4=170.5-((D1)*(.857)*D5)
1540 A2=COS(L7)*COS(L8)/COS(D1)
1550 A1=(COS(L7)*SIN(L8)*.917463-SIN(L7)*.397821)/COS(D1)
1560 A=ATN(A1/A2)
1570 GOSUB 1870
1580 R1=A
1590 L1=.065709822*T1

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1600 L=T*24*1.002738+6.646055+(L1-INT(L1/24)*24)
1610 L=(L-INT(L/24)*24)
1630 G=(L/24)*P5-R1
1640 IF G<P5 THEN 1670
1650 G=G-P5
1660 GOTO 1710
1670 IF G<0 THEN 1690
1680 GOTO 1710
1690 G=G+PS
1710 H=L6-G
1730 E3=COS(L5)*COS(H)*COS(D1)+SIN(D1)*SIN(L5)
1740 E2=SQR(1-(E3*E3))
1750 E=ATN((E3/E2)-(1/(61.33*E2)))
1755 F=ATN(E3/E2)
1760 IF E<0 THEN 2178
1770 IF E>I6*RS THEN 2178
1790 A2=SIN(D1)/(COS(L5)*COS(F))
1800 A2=A2-(SIN(L5)/COS(L5))*(SIN(F)/COS(F))
1810 A1=SIN(L5)*SIN(D1)+COS(L5)*COS(D1)*COS(H)
1820 A1=(SIN(H)*COS(D1))/SQR(1-A1^2)
1830 A=ATN(A1/A2)
1840 GO SUB 1870
1850 GOTO 2020
1870 IF A=0 THEN 1890
1880 GOTO 1930
1890 IF A2<0 THEN 1910
1900 GOTO 2010
1910 A=PS/2
1920 GOTO 2010
1930 IF A>0 THEN 1990
1940 IF A2<0 THEN 1970
1950 A=P5+A
1960 GOTO 2010
1970 A=PS+(A-P5/2)
1980 GOTO 2010
1990 IF A2=>0 THEN 2010
2000 A=A+PS/2
2010 RETURN
2020 IF (T-I1)>(2*I)/1440 THEN 2040
2030 GOTO 2050
2040 PRINT
2050 IF INT(B+.S)>9 THEN 2080
2060 S$="" "
2070 GOTO 2142
2080 IF INT(B+.S)>99 THEN 2110
2090 S$="" "
2100 GOTO 2142
2110 IF INT(B+.5)>999 THEN 2140
2120 S$="" "
2130 GOTO 2142
2140 S$="" ""
2142 Z1=FNA(A)
2144 Z2=FNA(E)
2146 Z3=FNA(G)
2148 Z4=FNA(D1)
2150 IF Z4<0 THEN 2163
2151 IF Z3<G1 THEN 2163
2152 IF Z3>G2 THEN 2154
2153 GOTO 2157
2154 IF Z3<G3 THEN 2159

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```

2155 IF Z3 >G4 THEN 2163
2156 GOTO 2161
2157 Y$="U"
2158 GOTO 2170
2159 Y$="W"
2160 GOTO 2170
2161 Y$="J"
2162 GOTO 2170
2163 Y$=" "
2170 PRINT $$;STR$(INT(B+.5)),Z1,Z2,Z3,Z4;Y$
2176 I1=T
2178 B=B+I
2180 Z=(B-INT(B/100)*100)-60
2190 IF Z<0 THEN 1290
2200 B=INT(B/100)*100+100+Z
2210 GOTO 1290
2220 NEXT N
2230 N=0
2240 PRINT
2260 PRINT
2270 PRINT"DO YOU WANT MORE INFORMATION";
2280 INPUT D$
2290 IF D$="YES" THEN 560
2300 END
OK
-
```

The following two scientific calculator programs were contributed by Shelby Ennis, W4WNH/8 and William Dayton, WA8BAH.

The two equations used for these programs are:

$$\text{Elevation} = \sin^{-1} ((\cos(\text{GHA-LONG}) \cdot \cos(\text{LAT}) \cdot \cos(\text{DEC})) + (\sin(\text{LAT}) \cdot \sin(\text{DEC})))$$

$$\text{Azimuth} = \cos^{-1} \left(\frac{\sin(\text{DEC})}{\cos(\text{EL}) \cdot \cos(\text{LAT})} - (\tan(\text{LAT}) \cdot \tan(\text{EL})) \right)$$

HP-55 Program Form

Phys., **1957**, **1** in RUN mode switch to PRGM mode Then key in the program

DISPLAY		KEY ENTRY	X	Y	Z	T	COMMENTS
LINE	CODE						
00							
01	34	RCL					
02	08	8					
03	71	X					
04	34	RCL					
05	05	5					
06	71	X					
07	34	RCL					
08	07	7					
09	34	RCL					
10	04	4					
11	71	X					
12	61	+					
13	32	G					
14	32	sin					
15	33	STO					
16	00	0					
17.	31	F					
18.	14	tan					
19.	34	RCL					
20	06	6					
21	71	-X					
22	34	RCL					
23	07	7					
24	34	RCL					
25	05	5					
26	81	f					
27	34	RCL					
28	00	0					
29	31	F					
30.	13	cos					
31	81	22	X ²	Y			
32	51	+					
33	32	G					
34	13	cos					
35	00	0					
36	34	RCL					
37	09	9					
38	31	F					
39	-48	X ² Y-48					
40	23	R↑					
41	23	R↓					
42	34	RCL					
43	02	2					
44	22	X ² Y					
45	51	-					
46	-00	GTO-00					
47	23	R↑					
48	23	R↓					
49	23	R↑					

HP-55 User Instructions

Title EME Antenna AZ and EL from Moon's GHA and Declination Pg. 2 cl 2
Per instrument Shashikant PONNIAWARA and William Davison WAARRAH

Note: Steps 3a and 3c take data in degrees, minutes and seconds and convert to decimal degrees. If the data are already in decimal degrees, enter data at step 3b and 3d directly. The Nautical Almanac gives the Moon data in degrees, minutes and tenths of minutes, rounding off the minutes to the nearest integer. This is a negligible additional error to the plus or minus one degree error of the program. Example 1: Degree, minute and second data entered as 26, 55, 00. Example 2: Degrees, minutes and tenths of minutes, entered as 26, 55.0. Example 3: Degrees, minutes and tenths of minutes, entered as -26, 53, 00. Example 4: Degrees, minutes and tenths of minutes, entered as 26, 55.1. The program does not take into account your antenna height, or beam bending.

HP-25 Program Form

Title...EME Antenna A.Z. and El from Moon's GHA, and Declination Page 1 of 2
Switch to PRGM mode, press [F2] , then key in the program

DISPLAY	LINE	CODE	REG ARRAY	COMMENT		
				X	Y	Z
00	01	23-02	STD 2			
	02	21	X \leftrightarrow Y			
	03	24-04	RCL 4			
	04	01				
	05	31	ENTER 1			
	06	14-04	F sin			
	07	23-06	STD A			
	08	22	Rt			
	09	00	14-05 F cos			
	10	23-02	RCL 2			
	11	14-05	F cos			
	12	61	X			
	13	24-05	RCL 5			
	14	14-05	F cos			
	15	61	X			
	16	24-02	RCL 2			
	17	14-04	F sin			
	18	24-05	RCL 5			
	19	14-04	F sin			
	20	61	X			
	21	51	+			
	22	22	15-04 G SIN -1			
	23	23-02	S (U) 7			
	24	74	R/S			
	25	14-16	F tan			
	26	24-05	RCL 5			
	27	14-06	F tan			
	28	61	X			
	29	24-02	RCL 2			
	30	14-04	F sin			
	31	24-05	RCL 5			
	32	14-05	F cos			
	33	23	X \leftrightarrow Y			
	34	24-07	RCL 7			
	35	14-05	F cos			
	36	36	X \leftrightarrow Y			
	37	21				
	38	39	-41			
	39	39	-15-05	G COS -1		
	40	33-00	SIN 0			
	41	24-06	BCL 6			
	42	15-41	G X \times 0			
	43	13-48	G TD 48			
	44	24-03	RCL 3			
	45	24-00	RCL 0			
	46	51	-			
	47	23-00	SIN 0			
	48	24-00	RCL 0			
	49	-				

HP-25 Program Form

Title EME Antenna AZ and El from Moon's GKA and Declination Page 2 of 2

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Enter program			
2	Store constant	160	STD 3	360
3	Store GHA position	Long.	G H → STD 4	Long. 0
	Note: key strokes "G" & "H" ← convert Deg., Min., Sec. to Decimal	Lat.	G H → STD 5	Lat. 0
	Degrees... omit these key strokes if data are already in decimal			
	Degrees			
	Enter Latitude as "negative" if south of the equator. (use "CHS" key).			
4	Key in Moon Data	GHA	G H → ENTER 1	
	(Enter southern Dec., as "negative").	Dec.	G H →	
5	Run program		R/S	
	E1 is also stored in Register #7, Az in #9.		R/S	
	For another Moon position go to step 4.			